HOME TELECARE FOR CHRONIC DISEASE MANAGEMENT

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Abstract - **We review the development of an Internet-enabled home clinical workstation for the management of chronic disease, and the implementation of a clinical trial to test the functionality, usability and effectiveness of the system in both a city and a remote country setting. The Home Telecare System integrates with established primary care services to provide a new paradigm of active disease management through the daily collection of clinical data and assessment of functional health status, and the provision of feedback for patient self-management and education. A novel Medications Management module is also implemented to permit on line variation of prescribed medications.**

Keywords - **Home Telecare, Chronic Disease Management,**

I. INTRODUCTION

Active disease management intervention strategies for chronic disease such as congestive heart failure (CHF) or chronic obstructive pulmonary disease (COPD) is increasingly common. The US experience with effective disease management has seen significant improvement in the following areas:

- *15% improvement in hypertension [1]*
- *40% reduction in mortality for patients with CHF [2]*
- *decreased nursing home admissions [2]*
- *more effective management of asthma, depression, epilepsy and AIDS [3].*

Home care and ambulatory care for patients with COPD is now an established service in many countries of the world and is beginning to demonstrate significant improvements in health care outcomes at reduced cost [4].

CHF is a complex clinical syndrome in which the heart and circulatory system are unable to meet peripheral metabolic demands. In the USA, around 1% of those under 55, 5% of those between 55 and 65, and 10% of those aged over 75 years suffer from CHF [5] and it is estimated that the number of elderly with CHF will more than double by the year 2030 [6]. After the onset of CHF the median survival time for women is 3.2 years while for men it is 1.7 years [7]. At the Prince of Wales (POW) hospital in Sydney's Eastern Suburbs, CHF was the 6th most common cause for acute admission to hospital in those aged over 50, and it was the most common cause for acute readmission.

COPD Ranks as the 4th leading cause of death in USA. Mortality rate rose 32.9% from 1979 to 1991 and age adjusted death rates for COPD rose 71% from 1966 to 1986.Over the same two decades death rates from all causes declined by 22% and for heart and cerebral vascular disease declined by 45% and 58% respectively. Increases in morbidity and mortality are particularly striking among older people who continue to smoke [8].

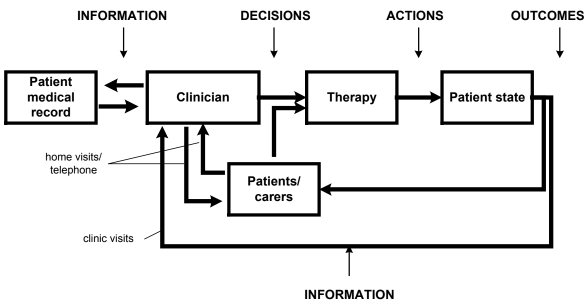

Fig. 1. Intensive Management Model for Chronic Disease [9]

COPD is the fourth leading cause of death in Australia and a significant cause of morbidity. It consumes $2.5 billion (8%) of Australian health expenditure and accounts for 8% of deaths. At the POW hospital, COPD was the 8th most common cause for acute admission to hospital in those aged over 50, and it was the 3rd most common cause for acute re-admission.

Applying a management model for home and ambulatory care as shown in Fig. 1, is however difficult for the patient as complex treatment instructions such as "*Monitor and track your blood pressure", "Recognize and report any symptoms", "Reduce your stress"* and *"Take the following six prescriptions"* may be difficult to follow. Access to doctors can also be difficult in times of need, patients often feel isolated and lack support and lifestyle changes are difficult to make.

Managing chronic disease is also difficult for the doctor and there is substantial evidence that patients with complex medical problems are difficult to treat cost effectively in the physician's office. In the typical office visit there is no time to educate and support, and no systems to monitor patient progress - all interactions need to be face-to-face. Although primary care physicians may be trained to manage the patient "holistically", behavior and life style modification is time consuming.

II. METHODOLOGY

Following extensive research which confirmed that an '*off-the shelf*' solution does not exist, we have developed a web-enabled Home Telecare System (HTS) for chronic disease management that integrates high quality clinical instruments, user services and interfaces in a single low

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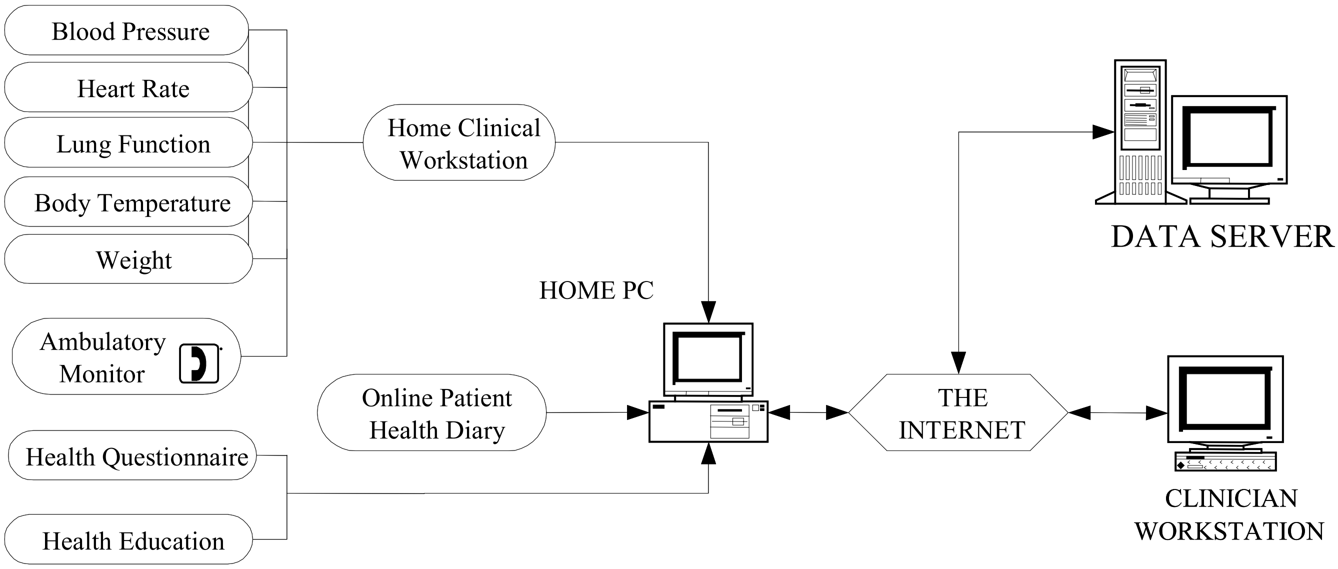

Fig. 2: Home telecare system structure for management of chronic disease.

cost, easy to use package. Since ancillary information and services such as questionnaires, daily health logs, medications management and access to health information are as important as physiological measurements, these become a key feature of the system design from the outset. We also introduced key feedback '*effectors*' for chronic disease management such as longitudinal tracking of health status, access to health education, lifestyle modification and medications management.

The complete HTS is shown schematically in Fig. 2. Access to the central server is controlled via password control for six different operational classes from Master User to Clinical Administrator to Clinician and Researcher. Access to key patient clinical records and demographics is strictly controlled, with researchers for example having only access to de-identified data.

The three key elements of the HTS are therefore the Home Clinical Workstation, the central data server and the user interfaces for patient and clinician access to longitudinal records stored in the central server.

The Home Clinical Workstation incorporates modules for:

- single lead electrocardiography, blood pressure, spirometry, weight and temperature measurements.
- Low power RF interface to ambulatory patient worn device with battery life in excess of 80 hours for:
  - telephone voice connection on activation of emergency button
  - triaxial accelerometer (monitoring of acceleration forces on the body along X, Y and Z axes).
- Ambient temperature, light and humidity

The electrocardiography module records a single Lead I lead from either contact plates or suction electrodes. The ECG module complies with IEC601.1 and is CF rated. The ECG screen during data recording is shown in Fig. 3.

The blood pressure module uses both oscillometric and auscultatory techniques and offers the clinician the option

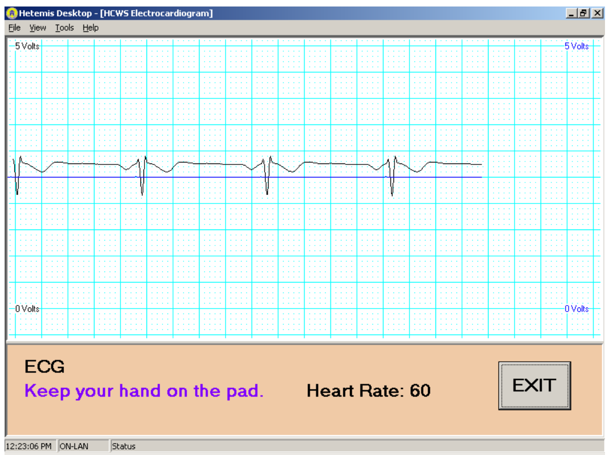

Fig. 3. Data collection screen for single lead ECG.

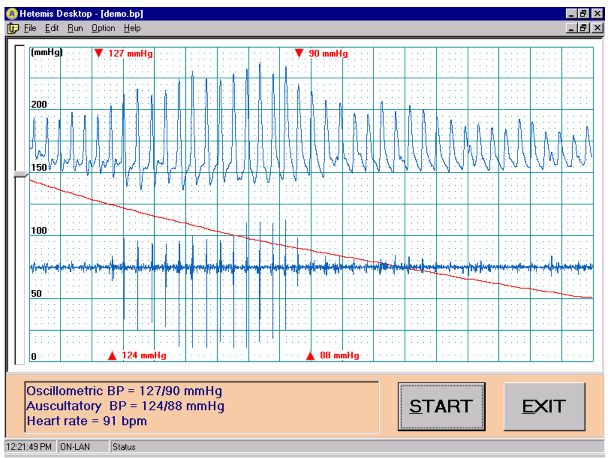

Fig. 4. Blood pressure collection module displaying both oscillometric and auscultatory waveforms.

of overriding the automatically derived systolic and diastolic pressures. A typical data collection screen is shown in Fig. 4. The spirometry module is based on hot wire anemometry and satisfies the technical standards of the American Thoracic Society for accuracy and

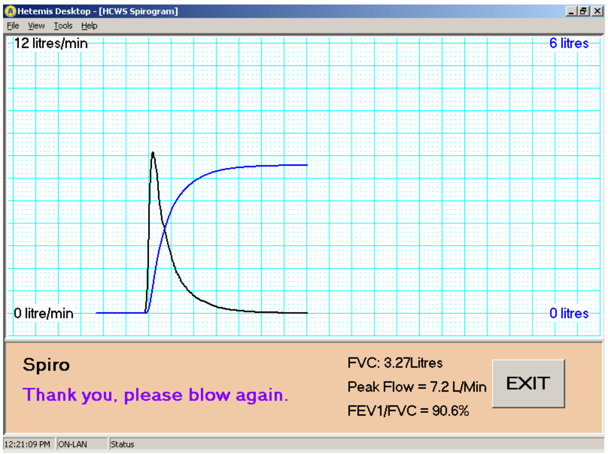

Fig. 5. Lung function module illustrating a forced expiratory manoeuvre resulting in a flow and volume waveform versus time.

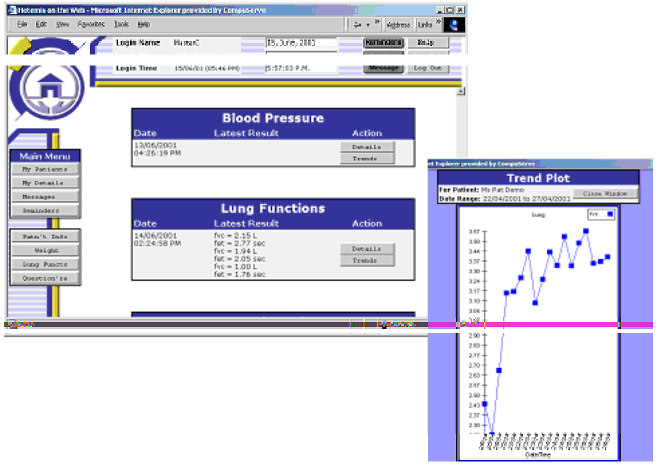

Fig. 6. Screen shots of the HTS web interface as seen by clinicians and researchers. The panel on the life shows a list of measurements for an individual patient. The right panel is a plot of longitudinal data showing the variation of lung capacity over time.

performance. A typical screen is shown in Fig. 5. A number of display modalities, including Flow-Volume curves, may be selected by the operator.

Operation of the instrumentation modules is intuitive and the user interfaces have been designed for ease of use even by frail and elderly patients. The patient is prompted throughout the recording session and most recordings require no more than one mouse click for execution. Clinical recordings are initiated through a scheduler, which generates auditory reminders consistent with the clinician requirements and the patient's own daily patterns. On completion of a recording session data is automatically uploaded and synchronized with the central server.

Tri-axial accelerometry

This module is fully described in another paper in these proceedings by Mathie et al. [9]. The ambulatory module is worn on the belt and transmits acceleration forces recorded on the body in the X, Y and Z directions over a range ±10g with a bandwidth of 30 Hz and 10 bit resolution. The wireless module operates at 433 MHz and provides 19.2 kbit of bandwidth over distances of approximately 30 metres. The unit also transmits a battery status bit, set by a fall in battery voltage below a preset value.

Tri-axial accelerometry is robust, offers high user compliance and permits the identification of changes in ambulatory patterns highly correlated to functional health status. It is also highly relevant to musculo-skeletal disorders, frailty in old age and a range of neuro-sensory disorders. Some of the parameters that can be derived from the use of tri-axial accelerometry include, orientation (standing, lying, sitting), ambulatory rhythm (slow walk, fast walk, shuffle), estimate of energy expenditure over any part of the day and simple count of "adverse" events.

HTS Web Interface

Fig. 6 illustrates two typical screens that are presented to the clinician to facilitate review of patient data. The clinician interface uses standard web browser technology and is therefore accessible anywhere an Internet connection is available. Trend graphs of key diagnostic, questionnaire and measurement parameters allow the clinician to rapidly review changes in patient health status.

Clinical Trial

A clinical trial funded by the Commonwealth Department of Health and Aged Care in Australia commences in mid June, 2001. This clinical trial involves patients with CHF or COPD who have been admitted to hospital in the previous year with either condition as their primary diagnosis. Patients must preferably be living independently at home and both patient and their primary care physician must agree to participate. Signed informed consent forms are required for both patient and doctor. Twelve patients (6 with CHF and 6 with COPD) have been selected from two metropolitan area health services in the Eastern and SE parts of Sydney and a similar cohort was selected from Wagga Wagga, a rural area in NSW approximately 800 km from Sydney.

The major project aims are to evaluate the performance of an integrated home telecare system for the management of CHF and COPD at home and to investigate its integration within established methods of health care delivery. Assessment includes demonstrating an improved efficiency in health care delivery and communication between relevant health care providers, (including clinicians, hospital and the community) and also with the patient. Demonstrating patient and clinician acceptability is also paramount. Ultimately, our aim is to prepare for a larger trial that will seek to demonstrate improved health care outcomes at reduced cost.

Operation of Trial

Monitoring of physiological parameters, health status questionnaires and other services are scheduled to fit in with patient life-style and preferred patterns. Clinicians can modify frequency and content of measurement protocols on-line. Data is synchronized and replicated at the central server immediately following collection. Ambulatory data

is collected locally, compressed and transmitted at a scheduled time, typically during the night.

During the trial, each patient's primary care physician will provide regular reviewing of patient data collected at home via a web browser. Medical intervention can be initiated in response to an observed change in patient health status by the GP or hospital clinician. The intention is for minimal interference between the normal pattern of doctor-patient relationship. Liaison with a clinical project manager (CPM) during the trial can occur in response to highlighted changes in a patient's clinical condition. Further liaison with hospital-based clinicians will be sought as required. An additional role for the CPM is to review and authorize on-line updating of medications initiated by the patient's doctor.

In response to patient activation of the emergency button, there is automatic dialing to a list of pre-selected local numbers (eg. to a carer) and/or 24 hour call service (e.g. Hospital Emergency Department). The CPM is notified of the emergency via an automatically generated SMS message as a back-up response.

In order to assess the implementation of the HTS in chronic disease management, it is crucial that any changes in the quality of health care achieved by use of this system are accurately assessed. The types of outcomes to be considered in this trial include improvement of health status in patients with CHF and COPD and improved communications (number and content) between GP's, patients, and hospital clinicians. Assessment of the usability and acceptance of home telecare technology from a clinician and patient perspective are important for ensuring continued use of the system. Finally, identifying costs in establishing a home telecare service for the representative sample of CHF and COPD patients will give an early indication of the cost effectiveness of implementing such services within more traditional model of healthcare delivery.

IV. Conclusions and Future Work

We have developed an integrated system for home management of chronic disease based on a low cost home clinical workstation supported by a very simple user interface and advanced web technology for access to health education and health status questionnaires. This system is designed to integrate with established clinical services and to provide the clinical case management team with timely and relevant clinical data for improving management of chronic disease at home. The full impact of this system on clinical practice, healthcare outcomes and cost benefits is yet to be evaluated and will require a larger clinical trial.

There are many potential enhancements to the Home Telecare System as it stands. The modular design of the system will allow for expansion and added functionality for the provision of additional clinical measurement such as pulse oximetry and glucometer readings. These measurements can be implemented in a flexible way to cater for individual patient requirements and levels of dependency. Future enhancements also include development of a clinical expert system for automatic identification of adverse trends in clinical data and the automatic generation of summary reports for the primary care physician.

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